Sandwich panels with integrated PV with freedom of size and color - PanelPV

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Project goals

- Development of Design and Process for Integrated Façade Panels
  - Sandwich panel with integrated opaque PV foil and degradation testing
  - Specific challenges: adhesion of PV foil to outer layer sandwich panel, weathering of PV foil
- Process Development for Translucent PV Foils
  - Laser processing for translucent PV foils, upscaling to full PV foil size, integration in sandwich panel, degradation testing
- Realization of colored demo-façade
  - Design and electronics for demo-façade
  - Business plan for market introduction

Integrated sandwich panels with PV foil

View of a finished sandwich panel with PV PanelPV

- Integration of opaque PV foil in sandwich panel with colored composite material
- Small reduction in efficiency of PV using high force sandwich process
- Weathering (DH = damp heat) results in large reduction of PV efficiency

Electrical measurements

	Power	Eff./SM
Pre-lam	32.30	12.0%
Laminated	32.17	11.9%
With foam	30.84	11.4%

*DH results with composite material**

Status	Remaining Power
Initial	100 %
1w in DH	97 %
3w in DH	81 %

** with additional moisture barrier*

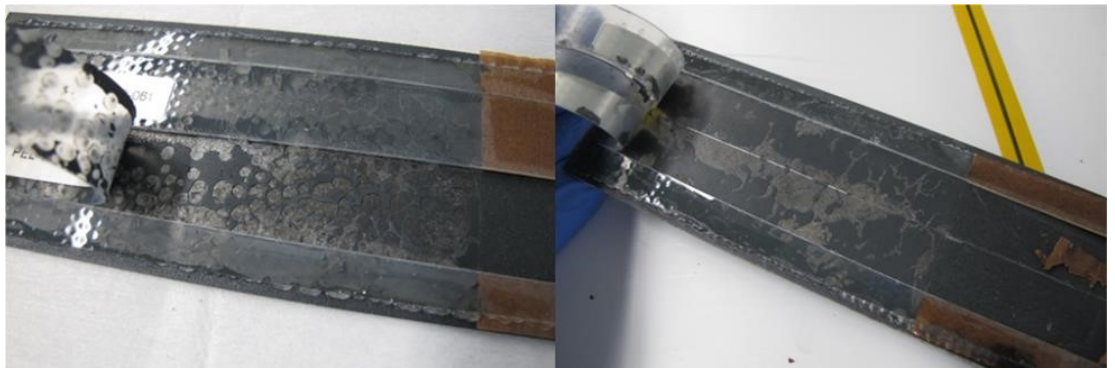
Integrated sandwich panels with PV foil

- Adhesion tests of PV foil on front side sandwich panel
  - Adhesion good for many materials, but environmental stress tests show reduced adhesion over time for most materials
  - One specific material could be used (limited amount of colors available)

Test	days
24h RT	1
7d RT	7
21d RT	21
24h 70°C	1
7d 70°C	7
7d 85°C	7
Damp Heat 336 hours	14
Damp Heat 672 hours	28
Damp Heat 1000 hours	42

Environmental stress sequence of adhesion tests

Adhesion measurement with Pull Force Tool



Test samples after environmental stress and adhesion measurement

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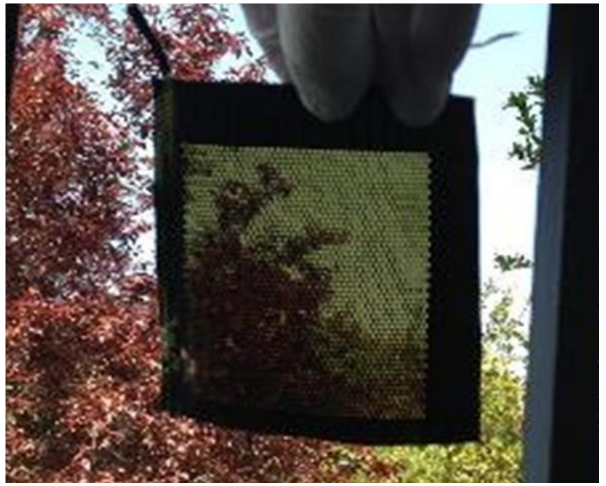
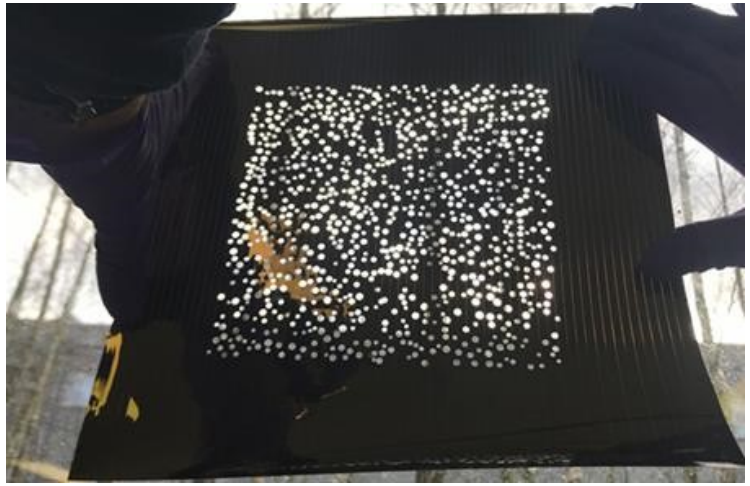
Translucent PV foils

- Laser processing for removal of CIGS
  - Challenge: yellowish color of the polyimide (PI) substrate of the PV foil
  - Use more transparent PI foils -> was not successful in the project
  - Remove the PI substrate

Patent application “Method for creating shunt free translucent flexible thin-film photovoltaic module” - WO 2021094481



First results of laser process by Sunpartner



Test sample with ~20% translucency by TNO

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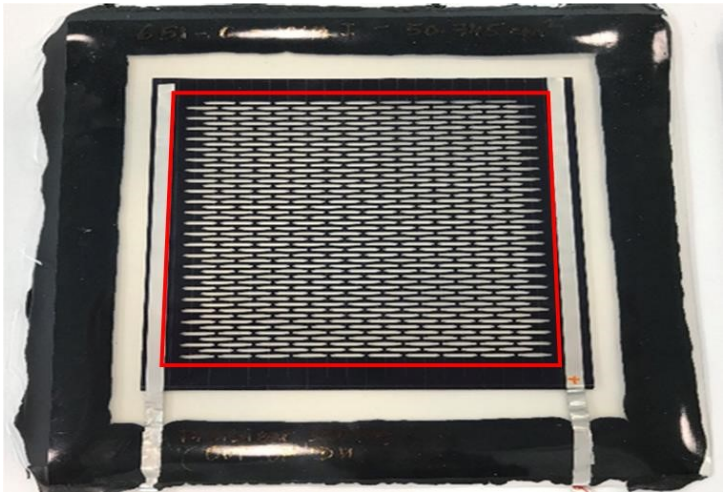
Translucent PV foils

- Laser processing for translucent PV foils
  - Optimization of laser patterning -> translucency and loss in current generation
  - Lamination with barrier foils and Damp Heat stress testing showed no electrical degradation after 300h

	651B Post Lamination	651C Post lamination
Jsc	62%	61%
Voc	103%	109%
FF	95%	102%
η	60%	67%
Rs_light	177%	178%
Rsh_dark	91%	330%

Percentage change of electrical parameters of 2 translucent samples



Laminated sample – 47.4% translucence on 85x85mm area (area inside red square)

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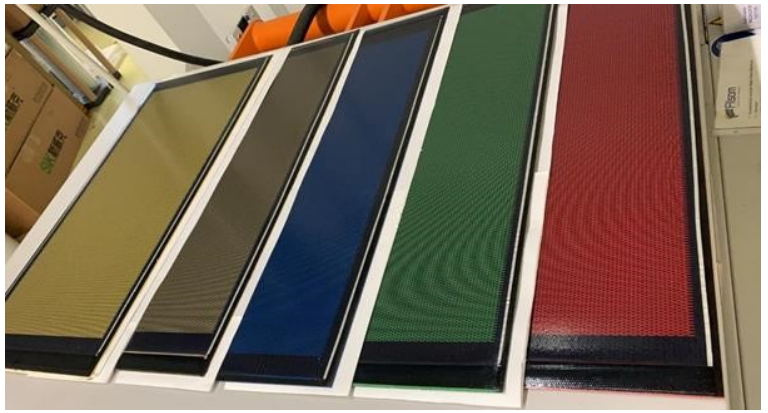
Large translucent PV foils for sandwich panels

- Upscaling laser process at TNO due to insolvency Sunpartner Technologies



- Production sequence:
  - Flisom: production PV foils
  - TNO: laser processing translucent PV foils
  - Flisom: lamination translucent PV foils to outer sheet sandwich panel and electrical assembly
  - Panelen Holland: production of sandwich panel with translucent PV on outer sheet

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Sandwich panel demo façade with integrated PV

- Demo façade installed at PanelenHolland
- 2 sizes of sandwich panels
- 5 different colors

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Sandwich panel demo façade with integrated PV

Conclusions

- Sandwich panels based on translucent CIGS modules of Flisom with acceptable efficiency reduction and stability are technically feasible
- Challenges for production:
  - Laser process speed and yield should be improved
  - Handling of PV foils and transport should be minimized
- For exploitation
  - Certification of final product is needed
  - Competition is big with alternative approach using enameled glass in front of PV module

Other findings

- Potential in window integration of PV -> truly translucent PV foil
- Transnational collaboration was great until the pandemic started
- Transport of sensitive PV materials should be avoided
- Notable factor for these type of R&I projects are the large differences in requirements from the local subsidy agencies, which potentially creates different approaches on reporting